

Occurrence of *Amphipholis squamata* (Echinodermata: Ophiuroidea) in relation to habitat in the Leschenault Inlet estuary

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Abstract

The occurrence of a cosmopolitan ophiuroid echinoderm, *Amphipholis squamata* (Delle-Chiaje) in the Leschenault Inlet estuary of south-western Australia has been recorded at varying intervals over a period of 17 years (1982-1999). This occurrence is noteworthy because the ophiuroid is inhabiting an estuary whereas most other records of the species in Western Australia are oceanic, and because the biogeographic range of the species is extended. During 1982-1987, *A. squamata* generally had sporadic low density populations in the Leschenault Inlet estuary, in restricted habitats mostly in areas with mud to muddy-sand substrate, moderate detritus levels, usually some seagrass and/or algae present, at the boundary between the middle to upper estuarine salinity fields, well-oxygenated water, and water temperature range of ca 15-30 °C. However, during August 1984 and September 1986 to March 1987, and in October 1990, *A. squamata* populations were dense, mainly located at the boundary between the middle to upper estuary. Since 1990, the species appears to have returned to its sporadic low density and restricted occurrence.

Keywords: ophiuroid, *Amphipholis squamata*, Leschenault Inlet, estuary, south-western Australia.

Introduction

The brittle star, *Amphipholis squamata* (Delle-Chiaje 1828), is a cosmopolitan ophiuroid echinoderm found in marine coastal waters of both the northern hemisphere (north-eastern America, northern Europe, the Mediterranean and the northern Indo-Pacific) and the southern hemisphere (*circum* South Africa, New Zealand and Australia). Around Australian coastal waters, *A. squamata* has been recorded as far north as Beagle Gulf and Melville Bay, Northern Territory, to as far south as Tasmania (Rowe & Gates 1995). In Western Australia, the species has been recorded ranging from as far north as Rowley Shoals to the Albany region and southern coast (Marsh 1986, 1991). In its *circum*-Australian distribution, the species has been found in a number of habitats including coral reefs, algae-covered rock platforms, and areas with sandy or muddy substrates.

This paper records *A. squamata* in Leschenault Inlet estuary, near Bunbury, south-western Australia (33° 17' S, 115° 41' E). This occurrence is noteworthy, firstly because the ophiuroid is inhabiting an estuary, whereas the majority of other records of the species in Western Australia are oceanic, and secondly because the biogeographic range of the species in an estuarine setting is extended. *A. squamata* is described in terms of its general biology and the spatial and temporal variation in abundance and distribution of the species with respect to different habitat settings within the estuary. Habitat variables (*i.e.* geomorphology, substrate, vegetation, water depth, temperature, salinity and oxygen content) are examined to determine any association with patterns of abundance and distribution of the animal. The known ecology of ophiuroids is applied to the specific situation existing in Leschenault Inlet estuary for *A. squamata*.

Setting

Leschenault Inlet estuary is located on the coast of the southern Swan Coastal Plain, south-western Australia. The Inlet is shallow and elongate, with a central mud-floored basin (1.5-2.0 m deep), a system of bordering seagrass-vegetated, shallower water, sand and muddy sand platforms and ramps (generally < 1 m deep), and a northern shallow water mud-floored flat (Fig 1A). It is separated from the Indian Ocean by the Leschenault Peninsula barrier dunes, and to the east it is bordered by a high ridge of sand and limestone (Mandurah-Australind Ridge). To the south and south-east there are deltaic complexes at the mouth of the Collie and Preston Rivers. Wurm & Semeniuk (2000) subdivide the estuarine system into numerous habitat units and hydrochemical zones. Relevant information on the habitats, as they relate to the occurrence of ophiuroids in Leschenault Inlet estuary, are described in Table 1.

Methods

Estuarine benthic invertebrate faunal surveys were carried out at Leschenault Inlet estuary from 1982 to 1987 by the V & C Semeniuk Research Group during the period 1982-1987, and these are supplemented by observations and collections of Deeley (School of Environmental Science, Murdoch University, *pers. comm.* 1998) and Bastyan (Water & Rivers Commission, Denmark *pers. comm.* 1998), and collections by this author in September 1998 and May 1999. This author and Deeley sampled with cylindrical cores as described below and Bastyan opportunistically collected a sample of algae in a 6-dram container.

Twenty-two sampling sites were established along 4 east-west transects to study benthic fauna in Leschenault Inlet estuary (Fig 1B). These transects and sampling sites, together with the physical and chemical characteristics of the water body considered to be relevant to the benthic fauna (oxygen concentration, temperature and salinity), are described in Wurm & Semeniuk (2000). Sampling sites

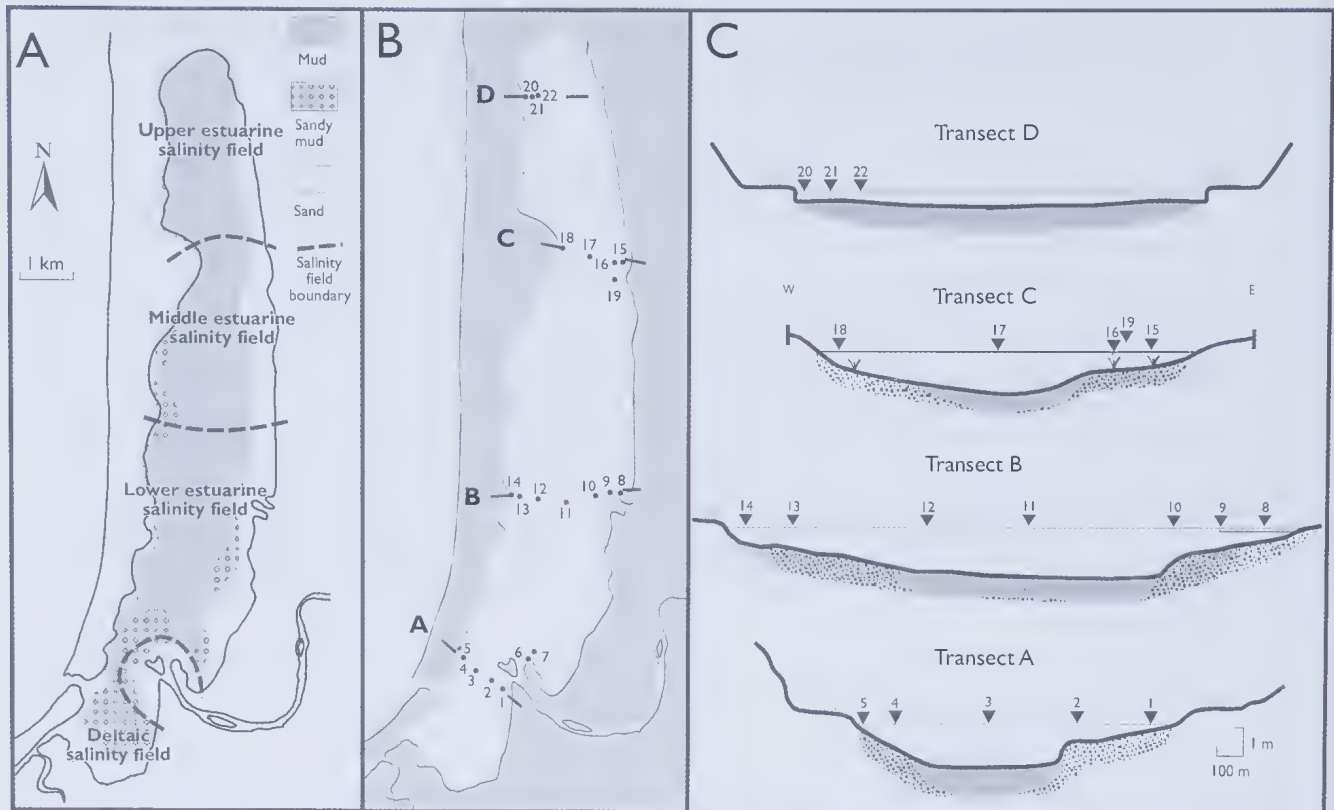


Figure 1. A: Generalised map of the habitats, showing location of platform and basin, substrate types, and salinity fields (after Wurm & Semeniuk 2000). B: Location of the Transects and the 22 sampling sites in the Leschenault Inlet estuary (after Wurm & Semeniuk 2000). C: Cross sections across estuary along the Transect C where the ophiuroid was most abundant, showing bathymetry, substrate types and sampling sites.

within a framework of water depths and substrates are shown in Fig 1C.

At the various study sites along the transects, benthic biota were sampled within a 10 m diameter homogenous area, annually, quarterly, to monthly, depending on location. Ophiuroids were sampled using two sizes of cores; a 25 cm x 25 cm x 25 cm square box corer and a 10 cm diameter x 15 cm long cylindrical corer (Semeniuk T A 2000; Wurm & Semeniuk 2000). At each sampling site one box core sample was taken to determine numbers of ophiuroids in the substrate by counting on-site; the sample was washed through a 1 mm sieve, and after counting, ophiuroids were released back to the environment. Similarly, five randomly-placed replicate cylindrical cores were used to determine ophiuroid numbers, and take into account patchiness in distribution, but were collected and stored for counting and further study in the laboratory. These small cores were washed through a 1 mm sieve in the field, and the sieved residues were fixed in 10% formalin, and transported to the laboratory where the ophiuroids were separated from other biota and then preserved in 1% phenoxitol. Ophiuroid specimens from these small cores were then counted and measured under a binocular microscope. Mean and standard deviation were calculated for the abundance figures of each sampling event.

Results

General biology

Over the five-year period 1982-1987, a total of 76 ophiuroid specimens were collected by small cores from

Leschenault Inlet estuary. The specimens ranged in disc diameter from 0.5 mm (minimum) to 3.0 mm (maximum). The majority of specimens were adults with disc diameters equal to or greater than 2 mm and a maximum arm length of 10 mm. Twelve per cent of the specimens were juveniles with disc diameters of 1.0 mm or less. Mean disc diameter of all *A. squamata* collected in the study was 1.8 mm. There was minor evidence of autotomy with a small number of specimens showing re-growth of one or more arms. Only one specimen from site 17 showed current indications of brooding with enlarged bursae evident.

Distribution of *A. squamata* (1982-1987)

Out of the 22 sites sampled over five years between 1982 and 1987 in Leschenault Inlet estuary, *A. squamata* occurred mainly along Transect C, at sites 15, 16, 17 and 18 (Table 1; Fig 2.). Characteristics of those sites where the ophiuroid has been most abundant (*i.e.* a mean number > 10 per 625 cm², *viz* sites 4, 15, 16, 17 and 18) have been summarised in Table 1 in terms of depth, substrates, seagrass cover, detritus content of the sediment, salinity, oxygen, and temperature.

Abundance over space and time (1982-1987)

Distribution of *A. squamata* varied spatially, with the larger population of ophiuroids in the relatively shallow water eastern and western platform and central basin deep water mud habitats at sites 15, 16, 17 and 18 (Figs 2, 3 & 4). However, the occurrence of *A. squamata* was temporally and spatially sporadic. *A. squamata* was not collected during every sample period and when present was not always found in every rep-

licate sample. Moreover, apart from one occurrence at site 17 in August 1984, no specimens were recorded at any of the sampling sites for a relatively lengthy period from November 1983 to August 1986.

Over the sampling period of 1982-1987, there were relative peaks in population densities in May 1983, August 1983, August 1984, and between September 1986 and March 1987. The most dense populations were at sites 15, 16, 17, and 18, though site 4 had a relatively dense population in February 1987. Even when the species was present fairly consistently in time, its abundance still varied during the year, with most ophiuroids present during spring through summer to autumn.

Occurrence in 1982-1987

Opportunistic sampling in 1990/91, 1995, 1998, and 1999 showed that *A. squamata* was present in the estuary beyond the 1982-1987 sampling period, sometimes in sites other than those which the ophiuroids most commonly inhabited (Fig 4).

During the sampling by the V & C Semeniuk Research Group in 1982-1987, as part of systematic survey of estuarine benthos in the estuary, 22 sites along Transects A, B, C and D were sampled. Ophiuroids were present mostly at

sites 15, 16, 17, 18 along Transect C, in shallow water seagrass-vegetated habitat, and seagrass-free deeper water, and additionally they were recorded at site A4 near "The Cut". Bastyan carried out systematic sampling over the whole inlet along numerous transects, in October 1990 as part of a widespread survey of aquatic vegetation of Leschenault Inlet estuary (Hill *et al.* 2000). During this survey ophiuroids were extremely abundant (hundreds of ophiuroids per square decimeter) along Transect C and over northern subtidal basin. *A. squamata* was epibiotic on dense mats of algae present at that time. A sample of algae with over 600 ophiuroid individuals in a 6-dram container was lodged with WA Museum. Bastyan again carried out systematic sampling over the whole inlet, for aquatic vegetation in April 1991, and found little evidence of ophiuroids. In 1995 Deeley sampled 5 sites located widely over the whole estuary and found that the ophiuroids occurred only at two sites, near C17 (6 individuals) and near the centre of Transect B (5 individuals). In September 1998 this author resampled site C16. No ophiuroids were noted from five 25 cm x 25 cm box cores. In May 1999 this author resampled sites A4, B9, B11, B13, C16, C17, C18. Only one ophiuroid individual was recorded at site C16 from 5 replicate box cores and 5 replicate small 10 cm cores.

Table 1. Description of the main sites where *A. squamata* occurred (data from Wurm & Semeniuk 2000).

Characteristic of the habitat	Site 4:Western seagrass vegetated shallow water platform	Sites 15 & 16:Eastern seagrass vegetated shallow water platform	Site 17:Central basin, seagrass-free	Site 18:Western seagrass vegetated shallow water platform
depth	average water depth of 50 cm	average water depth of 50 cm	average water depth of 130 cm	average water depth of 50 cm
substrate	muddy sand	muddy sand	mud	sandy mud
seagrass and algae	continuous seagrass meadows: dominantly <i>Halophila ovalis</i> and <i>Gracilaria</i> species	low seagrass meadows: dominantly <i>Halophila ovalis</i> and some <i>Ruppia maritima</i> ; algae: an unidentified <i>Phaeophyta</i> species, <i>Chaetomorpha</i> species (Chlorophyta) and to a minor extent <i>Gracilaria</i> species (Rhodophyta)	none	continuous seagrass meadows: dominantly <i>Halophila ovalis</i> , and algae
detritus in sediment	225 gm dry wgt/m ²	40-50 gm dry wgt/m ²	ca 10 gm dry wgt/m ²	70 gm dry wgt/m ²
salinity field	lower estuarine salinity field: mean salinity close to sea water, with a small standard deviation (winter: 32.0 ‰, summer: 43.5 ‰)	middle salinity field: mean salinity value higher than sea water and with a large standard deviation (winter: 29.5 ‰, summer: 48.5 ‰)	middle salinity field: mean salinity value higher than sea water and with a large standard deviation (winter: 29.5 ‰, summer: 48.0 ‰)	middle salinity field: mean salinity value higher than sea water and with a large standard deviation (winter: 30.0 ‰, summer: 46.0 ‰)
oxygen concentration	< 5 mg L ⁻¹	< 5 mg L ⁻¹	< 5 mg L ⁻¹	< 5 mg L ⁻¹
water temperature range	ca 15 °C in winter to ca 30 °C in summer	ca 15 °C in winter to ca 30 °C in summer	ca 15 °C in winter to ca 25 °C in summer	ca 15° C in winter to ca 30° C in summer

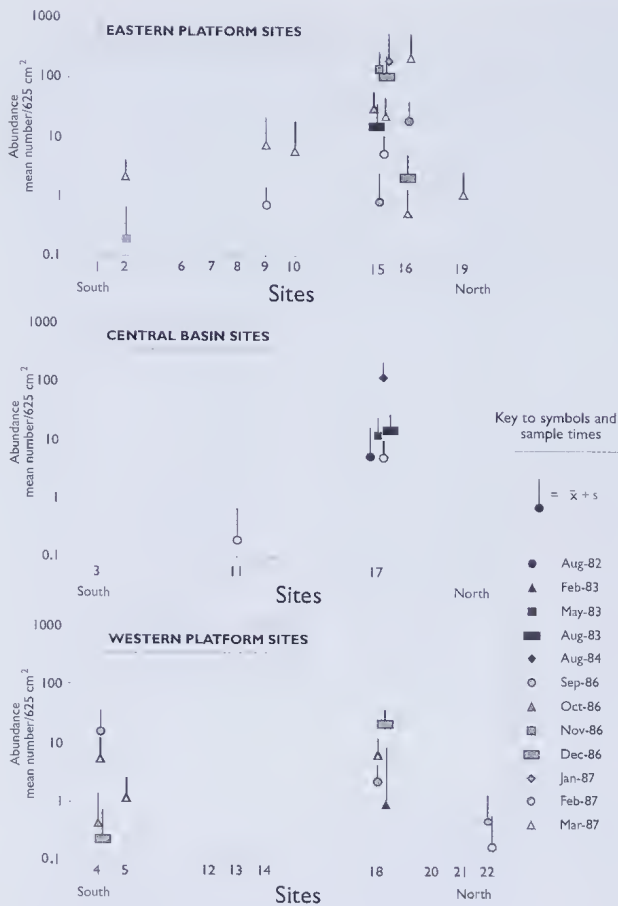


Figure 2. Mean abundance and positive standard deviation of the ophiuroid within each of the main habitat settings (*viz* eastern platform central basin, western basin) for the various sampling times (see Fig 1 for site locations). Table 2 notes which sites were sampled annually, quarterly, or monthly.

Discussion

Leschenault Inlet estuary presents an interesting environment for explaining the abundance and distribution of *A. squamata* with respect to habitat preferences encompassing biotic factors such as breeding strategy and mechanisms of dispersal, and abiotic factors such as substrate types, salinity, water temperature, water depth and water oxygen content. *A. squamata* is a globally-distributed species, adapted to the variable physical conditions of intertidal zones, and able to tolerate a range of environmental parameters (Enson & Foote 1980). Consequently, it is an opportunistic ophiuroid most likely to be able to survive under the estuarine conditions present in Leschenault Inlet estuary. In size, the specimens collected from Leschenault Inlet estuary were comparable with the marine Albany specimens collected by Marsh (1991) suggesting that normal growth expression was not limited by environmental conditions in the estuarine habitats.

In relation to the abundance of the animal, between 1982 and 1999, the occurrences may be summarised as follows;

1. from 1982-1986, *A. squamata* had sporadic low-level populations in the Leschenault Inlet estuary, in habitats mostly located along Transect C, the zone where



Figure 3. Histogram showing mean abundances only of the ophiuroid at individual sites within main habitat settings, with respect to sampling times (see Fig 1 for site locations).

the upper estuarine field adjoins the middle estuarine field;

2. in September 1986 to March 1987, *A. squamata* populations were dense, with the main populations again centred on Transect C, but with others along Transects A and D;
3. in October 1990, the ophiuroid was recorded as extremely abundant on vegetation along Transect C and in shallow water to the north; and
4. since 1990, the species appears to have returned to its sporadic low level occurrence, again in habitats mostly located along Transect C.

A range of heterogeneous habitats occurs in the Leschenault Inlet estuary, and *A. squamata* has populated a restricted number of them, *viz* the muddy sand seagrass-vegetated eastern and western shallow water platforms located in the mid-estuarine salinity field and the muddy vegetation-free central deep water basin. Comparisons of some key habitat features of the most populated sites and their implication to ophiuroid survival in Leschenault Inlet estuary are shown in Table 3 below.

A. squamata is a hermaphroditic viviparous species, not subject to the cyclic population variations reflecting larval recruitment, and consequently Hendler (1991) suggests that

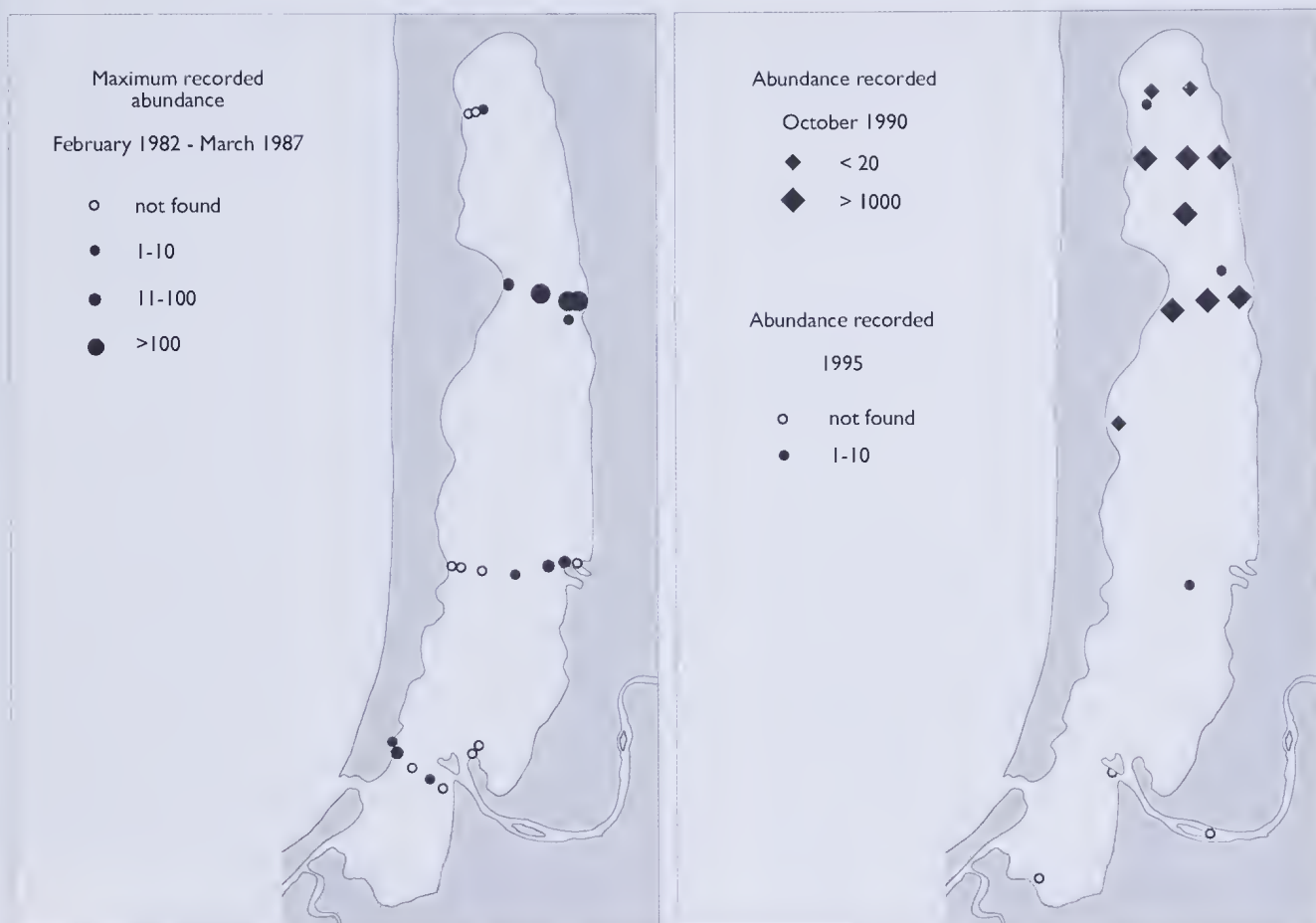


Figure 4. Occurrence of the *A. squamata* during the 1982-1987 sampling period, in 1990, and in 1995. Note that only positive occurrence results were shown for the 1990 information, even though the whole area of the estuary was systematically sampled.

brooding development of more than one cohort simultaneously may result in patchy recruitment and limited distribution. The ophiuroid may also migrate into environments by a mechanism termed "rafting dispersal", where the animal attaches to floating weed, a characteristic of some brooding ophiuroid taxa (Fell 1953). During the time of maximum abundance in October 1990, the ophiuroids were attached to local drifting bottom weed (Bastyan, Water & Rivers Commission, Denmark, *pers. comm.*) indicating that rafting dispersal may have been operating. Another method of dispersal which has been noted for ophiuroids is epizoism *e.g.* *Ophiocnemis marmorata* can "hitch-hike" on rhizostome jellyfish (Marsh 1998). It is possible that *A. squamata* may also occasionally adopt this method of dispersal. These latter mechanisms of dispersal may result in ophiuroids bypassing many possible suitable habitats before coming to reside in their final habitat. Thus, ophiuroid populations in Leschenault Inlet estuary could be maintained by two mechanisms; intra-estuarine maintenance (*i.e.* bursal brooding), and extra-estuarine rafting or hitch-hiking.

However, once established as a population within the estuary, the persistence of the ophiuroids would be determined by salinity (freshwater influences on local hypersalinity, and regions of stable near-oceanic salinity), hence they appear to contract to the region around Transect C. Once established as a population in the middle-upper estuarine region, the species may also maintain its populations over a number of favourable seasons by intra-estuarine reproduction.

Wide fluctuations in the abundance of ophiuroid populations in Leschenault Inlet estuary ranged from short duration population peaks (numbering in the thousands in October 1990) to virtual absence, even in its preferred habitats, for lengthy periods (*e.g.* mainly between November 1983 and August 1986). The temperature fluctuations described by Wurm & Semeniuk (2000) and the salinity record of Leschenault Inlet estuary over the period November 1983 to August 1986 show no apparent departure from the seasonal fluctuations evident for 1982-1987, indicating that temperature or salinity change probably did not eliminate the species from the estuary. The reasons for changes in abundance of the ophiuroids in Leschenault Inlet estuary over time is therefore unknown.

Overall, *A. squamata* occurs in Leschenault Inlet estuary as an opportunistic colonizing species which inhabits the more marine-like habitats consisting of shallow water muddy substrates, moderate to warm temperatures and less fluctuating, euhaline salinity found towards the northern end of the estuary. While in general the abundance and distribution of the ophiuroid was low and limited respectively (with the exception of occasional population explosions), *A. squamata* seems to be a persistent species within the Leschenault Inlet estuary. However, its mode of recruitment, either externally from marine sources via rafting/hitch-hiking, or internally from intra-estuarine populations, or a combination of both modes is worth further study.

Table 3. Comparisons of key habitat features of sites 15, 16, 17 and 18 in Leschenault Inlet estuary and their implications.

Habitat attribute	Sites 15, 16 & 18	Site 17	Implications
depth	50 cm	130 cm	globally, the species ranges from intertidal to continental slope (500 m) habitats, but in Leschenault Inlet estuary it inhabits essentially shallow water habitats
sediment type	muddy sand	mud	mud and muddy sand are the preferred substrates in Leschenault Inlet estuary: these are sediment types (amongst others) that Cherbonnier & Guille (1978), ascribe to <i>A. squamata</i>
seagrass	seagrass cover	seagrass-free	in situ macrophytes are not a determinant
oxygen	water column well oxygenated	water column well oxygenated	<i>A. squamata</i> possesses a high tolerance for low oxygen levels as a corollary of burrowing in anoxic sediments, thus oxygen is not a limiting factor
detritus	moderate to high content	low content	detritus content is not a determinant
freshwaterinfluences	not freshwater influenced	not freshwater influenced	freshwater potentially eliminated the species in the middle to southern parts of the estuary, where it is generally absent
marine water influences (proximity to the oceanic source)	marine derived, stable salinity	marine derived, stable salinity	ophiuroids reach their maximum abundance at sites distal from the oceanic source, where salinity fields are stable; they are uncommon both in hypersaline fields along Transect D, and deltaic fields along Transect A, implicating salinity as a determinant
temperature	ca 15 °C in winter to ca 30 °C in summer	ca 15 °C in winter to ca 25 °C in summer	temperature does not appear to be a determinant in Leschenault Inlet estuary

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